Dr. Abdalla Darwish Presidential Professor BIO

Dr. Darwish is a professor of physics, in 2014 was named Dillard University's first Presidential Professor he is also holds Ruth Simmons University Distinguished Professor and Optics and Photonic society SPIE Fellow. Darwish worked as associate professor at Al A&M University in 1993 where he supervised 7 graduate students (5 MS and 2PhD). He has been a Dillard University faculty member since 1998 and has served Dillard university in numerous administrative roles, including chair of the physics department, chair of the School of STEM, interim dean of the College of Arts and Sciences, and Associate Provost and Associate senior Vice President for Academic Affairs. Prof Darwish is an expert in thin film fabrication using the Pulse Laser Deposition technique. He has authored over 92 publications and book chapter in the areas of nonlinear optical materials, magnetic resonance, waveguides, thin film fabrication and optical sensors and filled five patents. Under his leadership, the physics department became a signature program for Dillard University, and holds a National standing in graduating more than 55% of African American in physics since 2000 by AIP.

Darwish has been able to secure over $15 million in grant funds as a PI or CoPI to establish many programs and research enterprises in physics and the School of STEM. In addition, Dr. Abdalla Darwish holds a public office where he has been serving as member of city of Kenner civil service board since its inception in 2006 until present. Dr. Darwish was awarded the Monte Lemann Award from the civil service league of the State of LA in Oct 2014.

In Details, Prof Darwish is an expert in Educational and research programs , recruiting and training middle and high school students and gear them toward STEM fields especially Physics and Engineering. In addition, Professor Darwish is specialized in many physics research fields, like Nonlinear optical materials (NLO), Electron paramagnetic Resonance (EPR), Infrared double Optical Spectroscopy, ion implantation, Fabrication of optical, chemical and Bio sensor devices using double and triple PLD concurrent MAPLE thin film fabrication technique which he invented. Darwish has authored over 92 publications in the areas of nonlinear optical materials, magnetic resonance, waveguides, thin film fabrication and sensors (www.researchgate.net) for full publications list and full manuscripts either read, or download).

Over the course of his tenure at Dillard, Darwish has been able to secure over $15 million in grant funds as a PI or CoPI to establish many programs and research enterprises in physics and the School of STEM as general such as the summer bridge program, **LS-LAMP consortium** (LA ALLIANCE FOR MINORITY PARTICIPATION) with SUBR ,we are in phase five until 2021 supported by NSF (Increase the number of minority obtained degrees in STEM),

GAELA consortium with Tulane University and LSU (Graduate Alliance for Education in LA) to increase the number of minority entering graduate schools funded by National Science Foundation,
TESSE consortium with University of New Hampshire and Penn State (Transform Earth Science Education System) to increase the number of teachers in STEM areas and enhance their training and experience in teaching and classroom preparation, this program trained over 85 STEM teachers from State of LA and made a difference after Hurricane Katrina ,

GAMP consortium (Geoscience Alliance to Enhance Minority Participation) with LSU. This program increased the number of minority students with MS and PhD in Geoscience field funded by National Science Foundation ,
AGAP program funded by National Science foundation "Comparison study between US and England for minority students attending graduate schools Funded by National Science foundation,
NASA- LA SPACE consortium to increase the research activities and research infrastructure related to NASA mission and vision and students training toward engineering fields,

NASA-NORC consortium for STEM retention in the city of New Orleans, Supported by NASA.

In the research area Professor Darwish before coming to Dillard University he was associate Professor at AL A&M University where he established two major research fields in the physics department one in Nonlinear optical materials and paramagnetic research and spectrometer (Bruker) and Carbon Dioxide Pulsed laser for isotope separation and nonlinear optical materials research. Prof Darwish supervised six graduate students as their graduate academic advisor, chair of the thesis and PhD research committees all completed their degrees (Directed the thesis and the Dissertation of 7 Graduate students in the areas of Engineering Design and Fabrication, Nonlinear Optical Materials, Electron Paramagnetic Resonance, and Laser Systems Fabrication (CO2, FIR) (2 Ph.D co-majors and 5 MS Major Academic advisor) all graduated Dr. William Bryant PhD, Dr. Mahdi Mogbel PhD, Mr. Garfield Percy MS (Private business, Atlanta), Mr. Robert Sliz MS (AL A&M University), Mr. Randolph Copland, MS (DOD), Mr. Jesse Mores MS (Aramco oil co.), and Dr. Tommy Thompsons (NASA).

At Dillard University he was funded by NASA-EPSCoR with Tulane University to study the Ablation of hard materials for space and material coating, and many other programs as the PI from the Air Force, Air Force Office of Scientific Research, Army Research office. Prof Darwish establish State-of-Art research infrastructure and Laser labs at Dillard University for Pulsed Laser Deposition and Ablation (Both PLD and MAPLE) of soft and hard materials program of materials for photonic and device fabrication and to train minority students in advanced research projects related to Defense and homeland security and increase the number of minority students going to graduate schools.

Here is some of the grant numbers which was completed or current with AFOSR and Army Research Office (FA9550-12-1-047, FA 9550-08-1-0363, FA9550-12-1-0068 (current), FA9550-10-1-0199, FA9550-10-1-0198, W911NF-11-1-0198, W911NF-14-1-0093, W911NF-14-1-0093, W911NF-15-1-0446 (Current), W911-16-1-0506 (Current)). In addition, Professor Darwish has a CRADA and JWS signed with the Army Research Lab for five years (2016-20210) (**"Novel Adaptable and Sensory Materials System Discovery".**

Capabilities research infrastructure at Dillard University:

1. Spectra Physics pulsed nanosecond lasers Nd:YAG laser 10 Hz and pulsed 50Hz
2. OPO pumped by Nd:YAG laser
3. Reflected High Energy Electron Deflector (RHEED)

4. PLD chamber 12inches,
6. MAPLE 12 inches chamber
7. New invention of PLD-MAPLE double and triple PLD/MAPLE 24 inches chamber
8. High speed Camera (1 M frame per second) to study the plasma and plumes in situ inside the Chambers
9. Thermal conductivity and electrical conductivity of thin films measurements setup
10. Atomic Force Microscope Bruker
11. XRF Bruker Tiger 8
12. XRD Dasher
13. FTIR and microscope Bruker
14. UV-VIS-IR spectrometer Cary Varian
15. Spectrograph and Raman spectrometer
15. 10, 20, and 30 tones automatic Hydrlic presses for pellet of Upconversion materials,
16 Scan Electron Microscope and Transmission Electron Microscope (JEOL) and all associated devices and support.
17. We are in process of acquisition of femtosecond laser.

Publications 92 publications and book chapter:

Please see www.researchgate.net for a complete list:

https://www.researchgate.net/profile/Abdalla_Darwish/stats

Patent and inventions:

1. Abdalla Darwish and Sergey Sarkisov, Method and apparatus for multi-beam pulsed laser deposition of thin films, US Provisional Patent Application No. 61/850,330. **Filed 2/14/2013**.
2. Abdalla Darwish, Paolo Mele, and Sergey Sarkisov, Nano-composite thermo-electric energy harvester and fabrication method thereof, Provisional Patent Application No. 62/071,116, Filed **9/15/2014**.
3. Abdalla Darwish and Sergey Sarkisov, Multiple beam pulsed laser deposition of composite films, US Patent Application No. US 14/158,567, Priority date Feb 14, 2013, Publication No. US 20140227461 A1. Continuation in Parts. Filed **10/5/2014**.
4. Abdalla Darwish, Paolo Mele, and Sergey Sarkisov, thermo-electric energy harvester and fabrication method thereof, continuation in parts with the Provisional Patent Application No. 62/071,116, Filed 9/15/2014
5. Abdalla Darwish, Paolo Mele, and Sergey Sarkisov, Nano-composite thermo-electric energy converter and fabrication method thereof, US Patent Application No. 14/853,674, Filed 9/14/2015.
6. Abdalla Darwish and Sergey Sarkisov, Method and apparatus for open-air multi-beam multi-target pulsed laser deposition, US Provisional Patent Application number 62/389,086, Submitted 2/12/2016.

Quad Charts for the current work at Professor Darwish research labs:

Laser deposition of polymer nanocomposite films

Dr. Abdalla Darwish, Dillard University, Grant number FA9550-12-1-0068

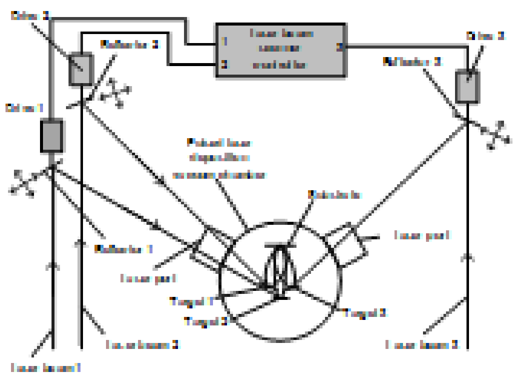
<u>Objective</u>: The main objective is to produce operationally feasible polymer nanocomposite films for sensor and light emitting applications using the pulsed laser deposition (PLD).

<u>Approach</u>: Polymer nanocomposites will be fabricated using the matrix-assisted pulsed laser evaporation (MAPLE), resonance infra-red PLD (RIR-PLD) and RIR-MAPLE. Fabricated nanocomposites will be characterized using the reflected high energy electron diffraction (RHEED), UV-visible optical absorption spectroscopy, atomic force microscopy (AFM), Fourier transform infra-red (FTIR) absorption spectroscopy and tested as chemical sensors and light emitters.

Statement of Work for Year 4

1. To complete assembling the new three-beam PLD system.
2. To conduct test runs of the new three-beam PLD system.
3. To conduct investigation of the formation of the plumes in the three-beam PLD system using the new ultra-fast video camera.
4. Investigate the properties of the polymer films deposited with the matrix-assisted pulsed laser evaporation (MAPLE) using FTIR absorption spectroscopy.
5. To investigate the process of resonant infra-red (RIR) MAPLE of polymer films using a a pulsed laser beam generated by the new tunable mid-infra-red (mid-IR) optical parametric oscillator (OPO) attached to the third channel of the PLD system.

Program progress: new 3-beam MAPLE system is being completed



Scientific Challenges

PLD of polymer nanocomposites is a very new field of research with few successful attempts made by research teams around the world. The most challenging will be the task of RIR-MAPLE deposition of polymer nanocomposites with an OPO laser source selectively tuned in resonance with the absorption bands of the vibrational modes of the frozen organic solvent matrix. The challenge here will be the preparation of the polymer target in a frozen solvent matrix and fine tuning of the laser to achieve heating of the matrix without decomposing the polymer target itself. Previously, this work has been done using very expensive tunable free electron lasers (FEL).

DoD Research and Education Program fro HBCU/MI FY 2016, BAA W911NF-16-R-0002

Multi-beam pulsed laser deposition of inorganic-polymer nanocomposite thermo-electric films for energy harvesting

PI: Dr. Abdalla Darwish, Dillard University, New Orleans, LA, Email: adarwish@bellsouth.net

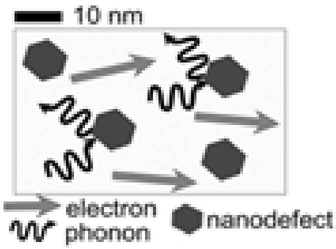


Diagram shows how introducing polymer nano-defects in nanocmopsite AZO film decreases thermoconduictivity and increases thermoelectric figure-of merit *ZT*>1.

Approaches to be utilized.

1. The thermoelectric nanocomposite AZO films will be deposited using MB-PLD process invented by PI.
2. The analysis of the films will be conducted using XRD, XRF, AFM, and FTIR. Also will be measured: electroconductivity, Seebeck coefficient , and thermoconductivity.
3. Performance parameters of the films: temperature of the substrate; electroconductivity; Seebeck coefficient; thermoconductivity; temperature difference between contacts; and the figure-of-merit *ZT* will be obtained and compared against those of pure AZO films and used to optimize the deposition process parameters in order to maximize figure-of-merit *ZT*.

Objectives of the project.

The prime goal is to find the optimal conditions of the patented multi-beam pulsed laser depostion (MB-PLD) process to enhance the figure-of-merit *ZT* of nanocomposite AZO-based films.

Objectives:

1. Fabrication of thermoelectric inorganic-polymer nanocomposite AZO films using MB-PLD.
2. Characterization of the films in terms of their structure, composition, and thermoelectric properties.
3. Analysis of the experimental data and improving the process in order to increase *ZT*.
4. Reporting and dissemination.
5. Training four undergraduate STEM students at Dillard through the participation in the project.

Anticipated outcomes:

1. New capabilities in PLD and characterization of TE materials will be further developed at Dillard.
2. Four undergraduate STEM students will be trained.
3. Impact on DoD:

a) Novel approaches to nanocomposite thermoelectric energy harvesters will be explored in line with the current Air Force interests in "material concepts that will provide low thermal conductivity but high electrical conductivity (thermoelectric) … " (BAA-AFOSR-2014-01, p.43)

b) The project matches the needs of the Electronic and Optical Materials and Devices (Code 6364) Branch of NRL that has PLD as its core competences (http://www.nrl.navy.mil/mstd/branches/6360/6364).

Laser deposition of polymer Nanocomposite films

Dr. Abdalla Darwish, Dillard University, Grant number FA9550-12-1-0068

Objective: The main objective is to produce operationally feasible polymer nanocomposite films for sensor and light emitting applications using the new invention of double pulsed laser deposition (DPLD).

Approach: Polymer nanocomposites will be fabricated using the matrix-assisted Double pulsed laser evaporation (D MAPLE) with new double Target design, resonance infra-red PLD (RIR-DPLD) and RIR-MAPLE. Fabricated nanocomposites will be characterized using the reflected high energy electron diffraction (RHEED), UV-visible optical absorption spectroscopy, atomic force microscopy (AFM), Fourier transform infra-red (FTIR) absorption spectroscopy and tested as chemical sensors and light emitters.

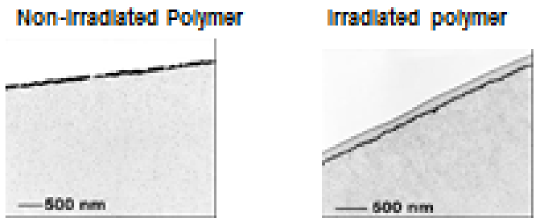
Uniqueness of approaches

1. Double-pulse laser deposition (3 Patents pending)
2. Composite targets will be prepared by freezing nanocolloids of metals and RE compounds in polymer solutions in organic solvents.
3. Polydispersed targets of frozen polymer solution and ice will used for RIR-MAPLE with tunable optical parametric oscillator source (MAPLE New Design)

Significance of results

The project will open new avenues for fabrication of advanced polymer nanocomosites for chemical sensors, light emitters, and other applications.

Program progress: forming of metallic interlayer in laser irradiated polymer



TEM cross section images of cured, metallized polymer films with and without laser irradiation at 351 nm. Note the metallic interlayer for the irradiated polymer.

Scientific Challenges

PLD of polymer nanocomposites is a very new field of research with few successful attempts made by research teams around the world. The most challenging will be the task of RIR-MAPLE deposition of polymer nanocomposites with an OPO laser source selectively tuned in resonance with the absorption bands of the vibrational modes of the frozen organic solvent matrix. The challenge here will be the preparation of the polymer target in a frozen solvent matrix and fine tuning of the OPO to achieve heating of the matrix without decomposing the polymer target itself. Previously, this work has been done using very expensive tunable free electron lasers (FEL).

Suggested research matching Quad, other research projects and collaboration can be arranged to use the facilities of Double and triple PLD and concurrent MAPLE chamber which was built solely by professor Darwish and patent pending:

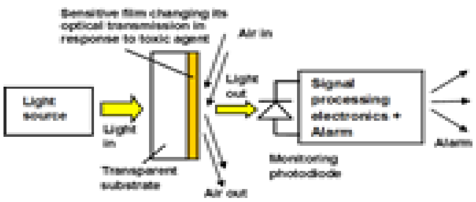
University Proprietary Dillard University

BAA Number: 17-S-4710, Objective 5.2. Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE), Topic R4121. DETECT-TO-WARN WEARABLE CHEMICAL SENSING PLATFORM

1/27/2017

Document ID:

Proposal Title: R4121 Detect-to-warn wearable chemical sensing platform based on nano-composite films



Principle of operation: optoelectronic reading of the reversible change of optical transmission of the nano-composite film in response to the toxic agent

Prototype of the wearable sensing platform

Operational and Performance Capability - Summary

- Automatically detects and alarms about toxic industrial chemical (TIC) vapors (ammonia and/or hydrazine) and nerve agent.
- Rapidly distinguishes and alerts on Lower Explosive Limit (LEL) hazards (15ppm).
- Has detection sensitivity levels close to permissible exposure limits (PEL) (50ppm time weight average - TWA) and acute exposure guideline levels (AEGL-1) (30 ppm for 10 min).
- The sensor response time is less than 30 seconds (Threshold) and 5 seconds (Objective).
- The wearable chemical sensor dimensions will not exceed 2 inches × 2 inches with a maximum of 0.5 inches in thickness.
- The sensor badge will have at least six months of shelf life and weigh less than 100 g including the batteries.
- The cost of the sensor and its components will be affordable enough to be used as a disposable badge.

Technical Approach

Use concurrent multi-beam multi-target pulsed laser deposition (MBMT-PLD) method to make sensing polymer nanocomposite films. Develop and demonstrate wearable sensing platform warning about presence of toxic industrial vapors and nerve agents (ammonia, hydrazine, and a nerve agent – an organophosphate, such as DFP, could be a simulant).

Phase 1 Tasks

- Adapting new MBMT-PLD method for making sensing films based on polymer PMMA host, indicator dye, and metal/fluoride nano-particles.
- Building the prototype optoelectronic reader of the change of the optical transmission of the nano-composite film and alarm.

Phase 2 Tasks

- Designing testing setup: exposure of the prototype to toxic agents and measuring response.
- Lab testing.
- Data analysis and conclusions on feasibility.

University Proprietary

Rough Order of Magnitude (ROM) Cost and Schedule

Phase 1 – ROM $40,000, Period of Performance (POP) 4 months

Exit criteria: Demonstrated working prototype and responsive to toxic vapors. Exit criteria: responds to LEL and AEGL-1 in less than 30 sec.

Phase 2 – ROM $80,000, POP 8 months

Exit criteria: Government validation and verification to System Requirements Specification (SRS).

Total POP : 12 months; Total Cost: $120,000

Products and Deliverables

Phase 1: SRS, Monthly Status Reports (MSRs), Test Strategy/Plan, and Technical Report (Design and the Prototype).

- Proof of concept demonstration

Phase 2: MSRs; Test Report; SRS updates; Final Technical Report; User Manuals; and Training Package.

- Functioning and validated sensor prototype, associated software licensing for initial setup.

University Contact Information

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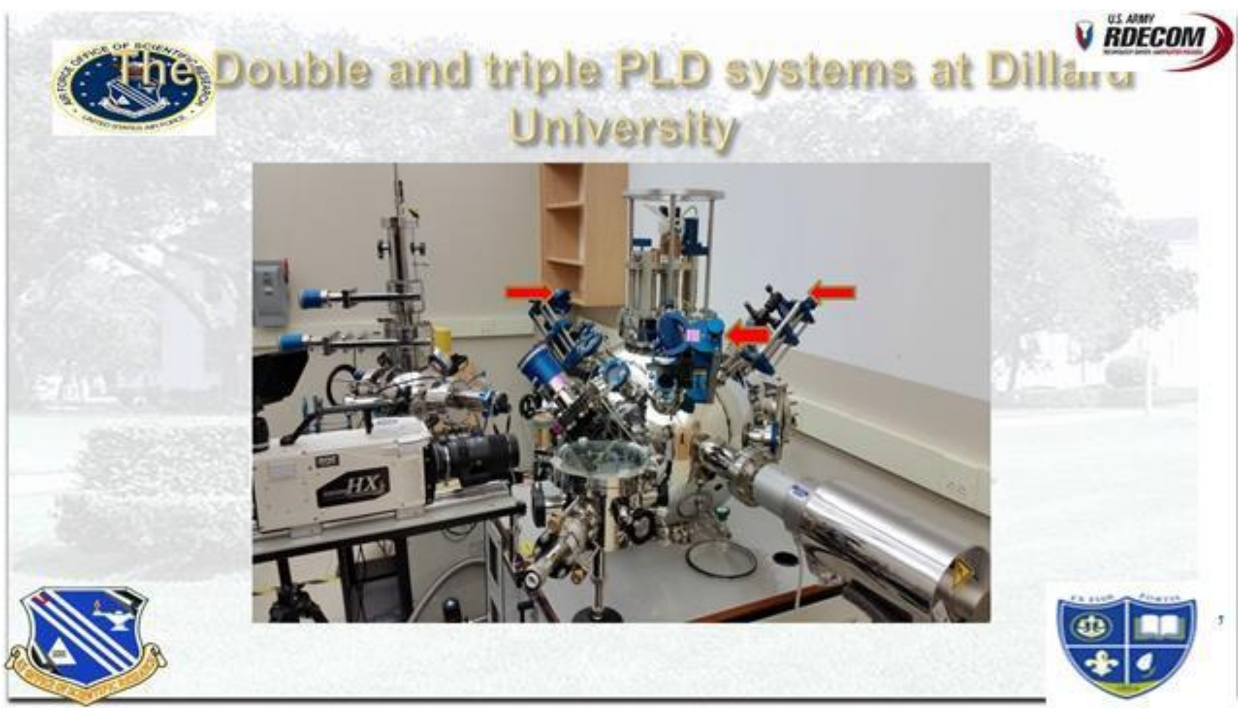
Laser and research labs portfolio :



ysics students research team at Dillard University (Last year 2016 physics program placed four students in graduate schools. All have been trained in the laser lab with support from AF, AFOSR, Army RDECOM